Time-Sensitive Value Calculator

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Counting Time: A New Tool that Estimates the Value of Efficiency and other DERs
April 13, 2022

This work was funded by the U.S. Department of Energy Building Technologies Office, under Contract No. DE-AC02-05CH11231.

Logistics

- We are recording the webinar.
- Because of the large number of participants everyone is muted.
- Please use the Q&A box to send us questions at any time during the presentations.
- We will put the link to the slides in the Q&A box. We will send links to the recording and slides to everyone that registered for the meeting a few days after the webinar.

Project Team

JP Carvallo

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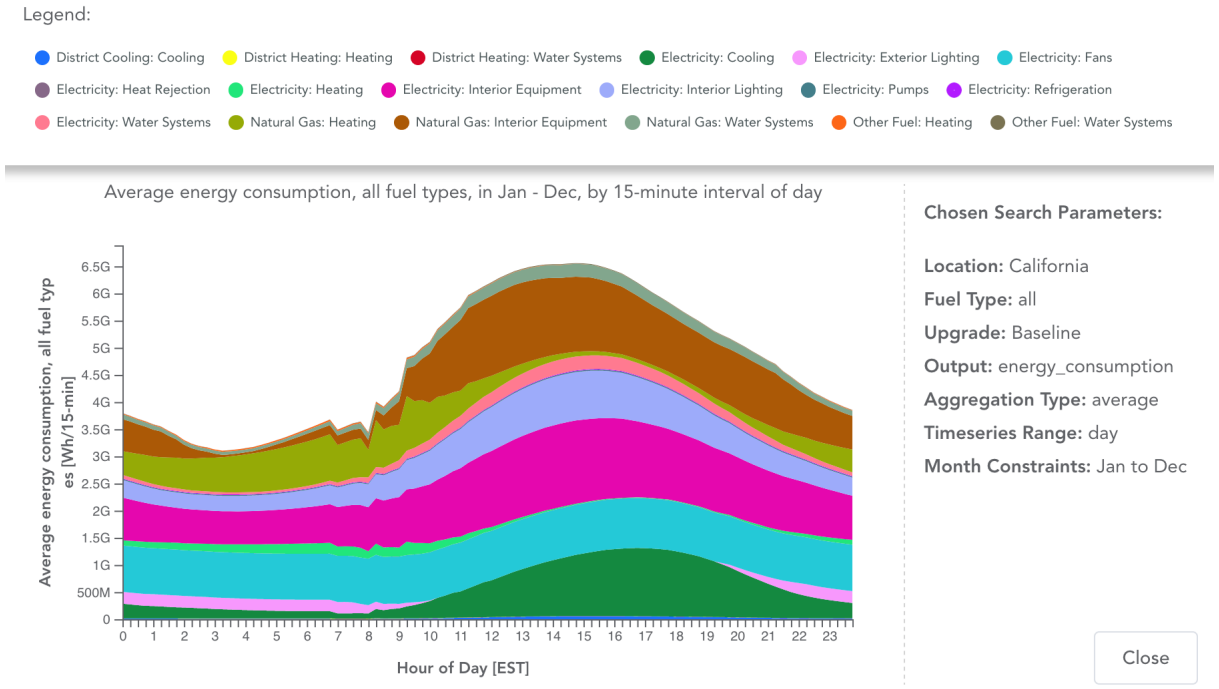
What is the time-sensitive value of energy efficiency?

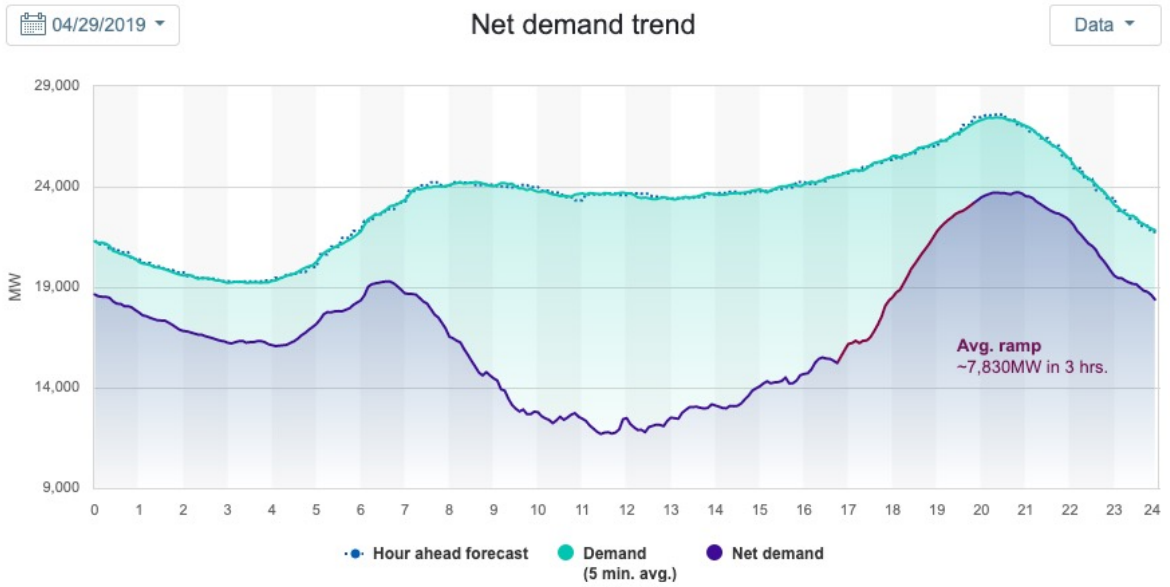
- Time-sensitive value of energy efficiency considers *when* energy efficiency occurs and the *economic value* of the energy or demand savings to the electricity system at that time.

Measure Shape



Source: ComStock

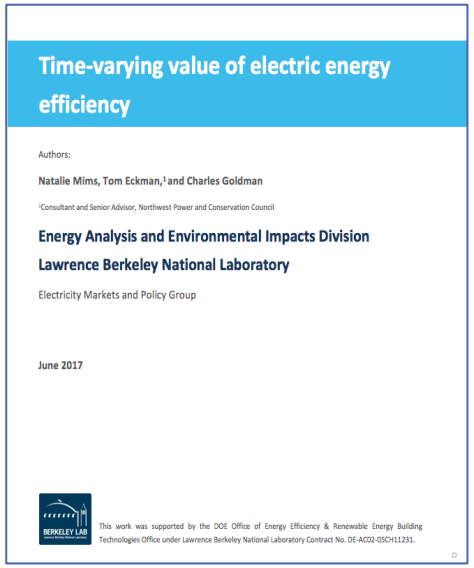
Economic Value



Source: CAISO

Project background

- The Department of Energy (DOE) has supported best practices for the evaluation of energy efficiency programs for many years.
- Over the last several years, DOE and LBNL have elevated the discussion of the time-sensitive nature of efficiency benefits, in part by publishing multiple reports on the time-sensitive value of efficiency.


Time-varying value of electric energy efficiency

Authors:

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Energy Analysis and Environmental Impacts Division

Lawrence Berkeley National Laboratory

Electricity Markets and Policy Group

June 2017

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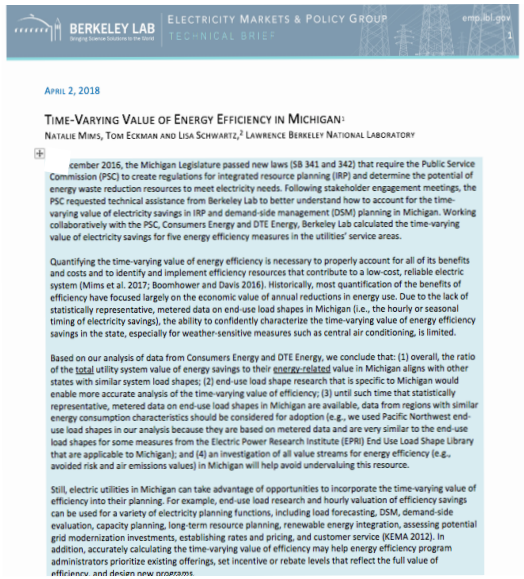
[June 2017](#)
technical report


BERKELEY LAB | ELECTRICITY MARKETS & POLICY GROUP | TECHNICAL BRIEF

APRIL 2, 2018

TIME-VARYING VALUE OF ENERGY EFFICIENCY IN MICHIGAN[1]

NATALIE MIMS, TOM ECKMAN AND LISA SCHWARTZ,[2] LAWRENCE BERKELEY NATIONAL LABORATORY

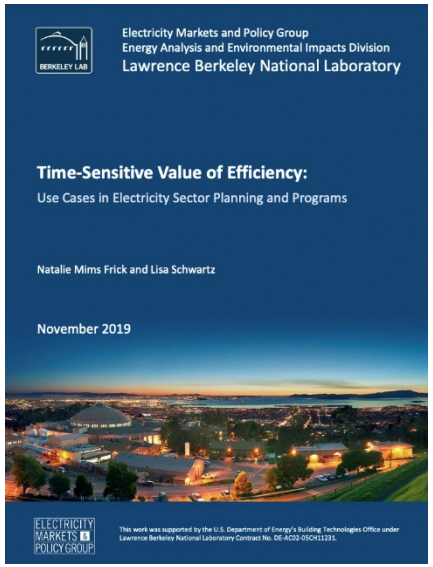
cember 2016, the Michigan Legislature passed new laws (SB 341 and 342) that require the Public Service Commission (PSC) to create regulations for integrated resource planning (IRP) and determine the potential of energy waste reduction resources to meet electricity needs. Following stakeholder engagement meetings, the PSC requested technical assistance from Berkeley Lab to better understand how to account for the time-varying value of electricity savings in IRP and demand-side management (DSM) planning in Michigan. Working collaboratively with the PSC, Consumers Energy and DTE Energy, Berkeley Lab calculated the time-varying value of electricity savings for five energy efficiency measures in the utilities' service areas.

Quantifying the time-varying value of energy efficiency is necessary to properly account for all of its benefits and costs and to identify and implement efficiency resources that contribute to a low-cost, reliable electric system (Mims et al. 2017; Boomhower and Davis 2016). Historically, most quantification of the benefits of efficiency have focused largely on the economic value of annual reductions in energy use. Due to the lack of statistically representative, metered data on end-use load shapes in Michigan (i.e., the hourly or seasonal timing of electricity savings), the ability to confidently characterize the time-varying value of energy efficiency savings in the state, especially for weather-sensitive measures such as central air conditioning, is limited.

Based on our analysis of data from Consumers Energy and DTE Energy, we conclude that: (1) overall, the ratio of the total utility system value of energy savings to their energy-related value in Michigan aligns with other states with similar system load shapes; (2) end-use load shape research that is specific to Michigan would enable more accurate analysis of the time-varying value of efficiency; (3) until such time that statistically representative, metered data on end-use load shapes in Michigan are available, data from regions with similar energy consumption characteristics should be considered for adoption (e.g., we used Pacific Northwest end-use load shapes in our analysis because they are based on metered data and are very similar to the end-use load shapes for some measures from the Electric Power Research Institute (EPRI) End Use Load Shape Library that are applicable to Michigan); and (4) an investigation of all value streams for energy efficiency (e.g., avoided risk and air emissions values) in Michigan will help avoid undervaluing this resource.

Still, electric utilities in Michigan can take advantage of opportunities to incorporate the time-varying value of efficiency into their planning. For example, end-use load research and hourly valuation of efficiency savings can be used for a variety of electricity planning functions, including load forecasting, DSM, demand-side evaluation, capacity planning, long-term resource planning, renewable energy integration, assessing potential grid modernization investments, establishing rates and pricing, and customer service (KEMA 2012). In addition, accurately calculating the time-varying value of efficiency may help energy efficiency program administrators prioritize existing offerings, set incentive or rebate levels that reflect the full value of efficiency, and design new programs.

April 2018
[technical brief](#)


Electricity Markets and Policy Group
Energy Analysis and Environmental Impacts Division
Lawrence Berkeley National Laboratory

Time-Sensitive Value of Efficiency:

Use Cases in Electricity Sector Planning and Programs

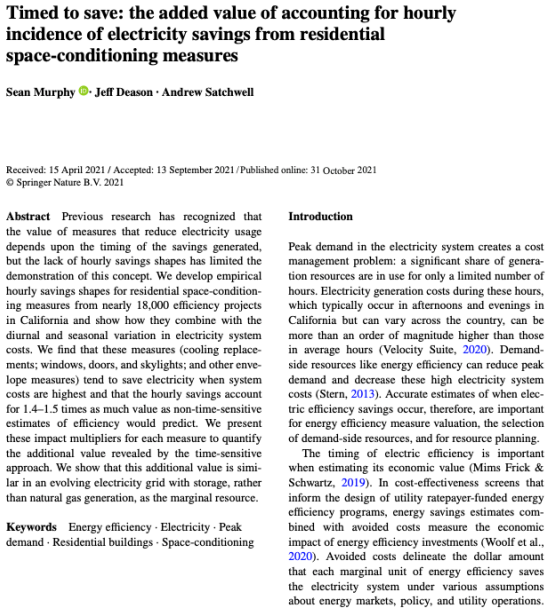
Natalie Mims Frick and Lisa Schwartz

November 2019

ELECTRICITY MARKETS & POLICY GROUP

This work was supported by the U.S. Department of Energy's Building Technologies Office under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

November 2019
[technical brief](#)


Timed to save: the added value of accounting for hourly incidence of electricity savings from residential space-conditioning measures

Sean Murphy · Jeff Deason · Andrew Satchwell

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Abstract Previous research has recognized that the value of measures that reduce electricity usage depends upon the timing of the savings generated, but the lack of hourly savings shapes has limited the demonstration of this concept. We develop empirical hourly savings shapes for residential space-conditioning measures from nearly 18,000 efficiency projects in California and show how they combine with the diurnal and seasonal variation in electricity system costs. We find that these measures (cooling replacements; windows, doors, and skylights; and other envelope measures) tend to save electricity when system costs are highest and that the hourly savings account for 1.4–1.5 times as much value as non-time-sensitive estimates of efficiency would predict. We present these impact multipliers for each measure to quantify the additional value revealed by the time-sensitive approach. We show that this additional value is similar in an evolving electricity grid with storage, rather than natural gas generation, as the marginal resource.

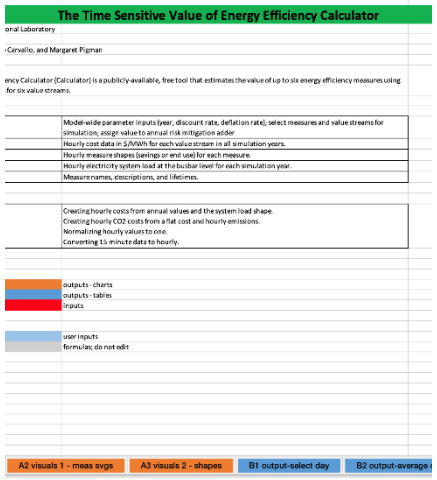
Keywords Energy efficiency · Electricity · Peak demand · Residential buildings · Space-conditioning

Introduction

Peak demand in the electricity system creates a cost management problem: a significant share of generation resources are in use for only a limited number of hours. Electricity generation costs during these hours, which typically occur in afternoons and evenings in California but can vary across the country, can be more than an order of magnitude higher than those in average hours (Velocity Suite, 2020). Demand-side resources like energy efficiency can reduce peak demand and decrease these high electricity system costs (Stern, 2013). Accurate estimates of when electric efficiency savings occur, therefore, are important for energy efficiency measure valuation, the selection of demand-side resources, and for resource planning.

The timing of electric efficiency is important when estimating its economic value (Mims Frick & Schwartz, 2019). In cost-effectiveness screens that inform the design of utility ratepayer-funded energy efficiency programs, energy savings estimates combined with avoided costs measure the economic impact of energy efficiency investments (Woolf et al., 2020). Avoided costs delineate the dollar amount that each marginal unit of energy efficiency saves the electricity system under various assumptions about energy markets, policy, and utility operations.

April 2021
[journal article](#)


The Time Sensitive Value of Energy Efficiency Calculator

oratory

Carvallo, and Margaret Pigman

ency Calculator (Calculator) is a publicly-available, free tool that estimates the value of up to six energy efficiency measures using for six value streams.

Model-wide parameter inputs (year, discount rate, deflation rate); select measures and value streams for simulation; assign value to annual risk mitigation adder

Hourly cost data in $/MWh for each value stream in all simulation years.

Hourly measure shapes (savings or end use) for each measure.

Hourly electricity system load at the busbar level for each simulation year.

Measure names, descriptions, and lifetimes.

Creating hourly costs from annual values and the system load shape.

Creating hourly CO2 costs from a flat cost and hourly emissions.

Normalizing hourly values to one.

Converting 15 minute data to hourly.

outputs - charts

outputs - tables

inputs

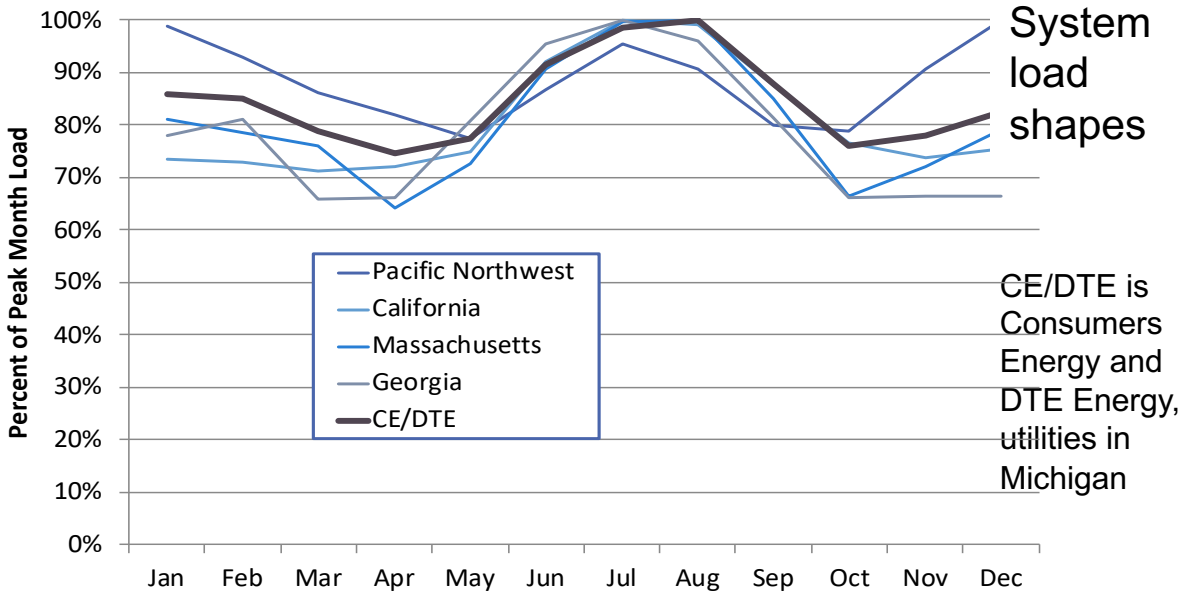
user inputs

formulas; do not edit

A2 visuals 1 - meas svgs | A3 visuals 2 - shapes | B1 output-select day | B2 output-average

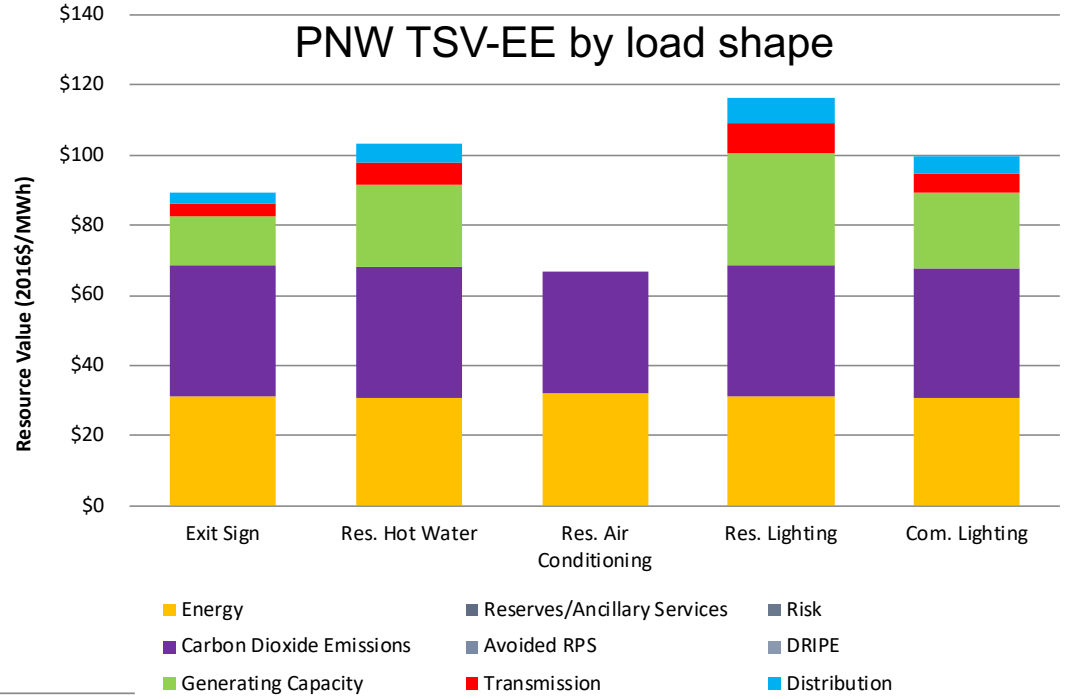
February 2022
[calculator](#)

Quantifying the time-sensitive value of energy efficiency for 5 regions

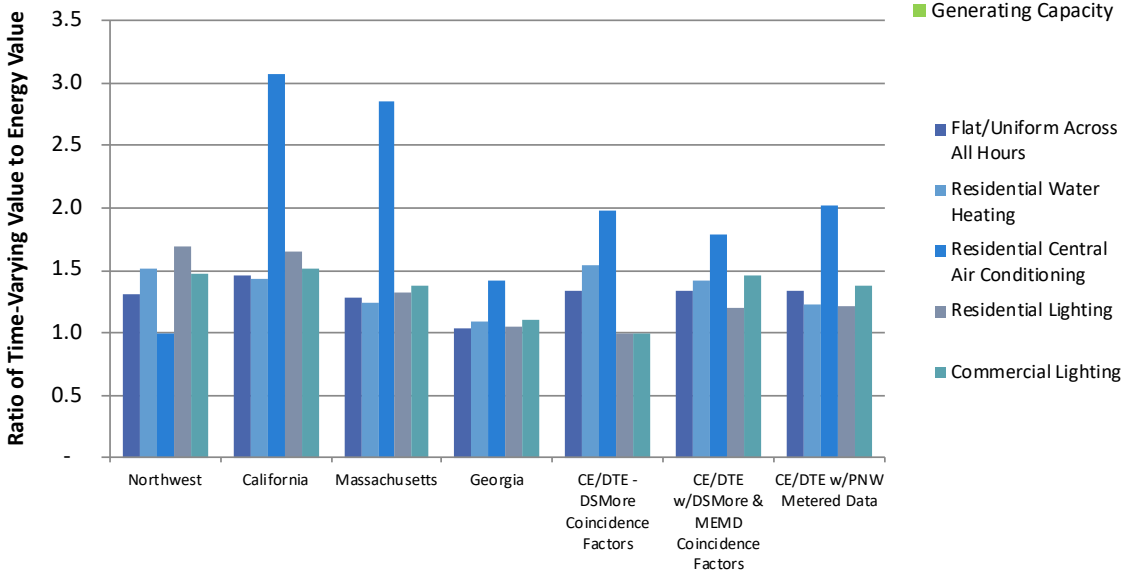


System load shapes

CE/DTE is Consumers Energy and DTE Energy, utilities in Michigan



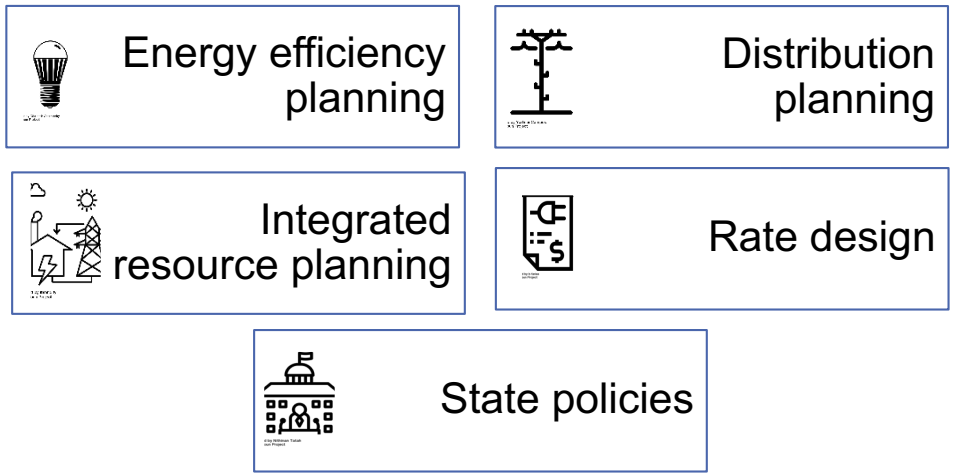
Results: Total utility system value of savings compared to only their energy value

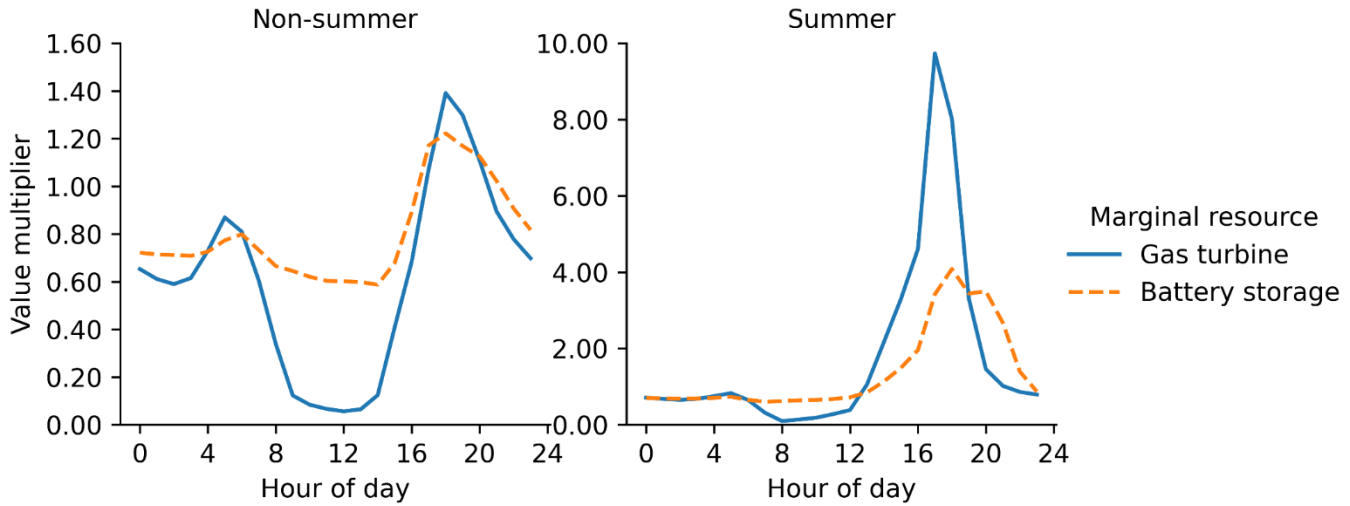


Notes: The flat load shape is an exit sign. Energy value includes: energy, risk, carbon dioxide emissions, avoided RPS and DRIPE, as applicable if reported. Total time-varying value includes all energy values and capacity, transmission, distribution and spinning reserves. Ratios are calculated by dividing total time-varying values by energy-only values.

Time-sensitive value use cases

- *Examples of Time-Sensitive Value of Efficiency in Electricity Sector Planning and Programs*
- Study identifies 5 use cases that consider the time-sensitive value of efficiency





- *Timed to save: the added value of accounting for hourly incidence of electricity savings from residential space-conditioning measures*
- Hourly savings shapes for residential space conditioning measures were developed from 18,000 efficiency projects in California
- Findings include that using time-sensitive valuation of savings increased value by 37-53%, and that the marginal resource impacts the value of the efficiency savings

Project need

- Understanding the value of efficiency, and other distributed energy resources* on a more granular time-scale is a critical component to identifying an affordable, equitable pathway to a decarbonized electricity grid.

- Utilities, public utility commissions and stakeholders have increased interest in how efficiency and other DERs can provide value to the electricity system as changes due to increased adoption of distributed energy resource, technology cost reductions and generation retirements emerge.

- Determining the time-sensitive value of efficiency can help these audiences to craft efficiency plans and programs that aid in achieving their energy goals, ranging from implementation of a reliable, low-cost electricity system to reduced air pollutant emissions.

- However, there is a lack of publicly available data and tools that allow regulators, state energy offices, utilities, and advocates throughout the U.S. to assess the time-sensitive value of energy efficiency.

*Efficiency and other DERs are collectively referred to as *measures* hereafter.

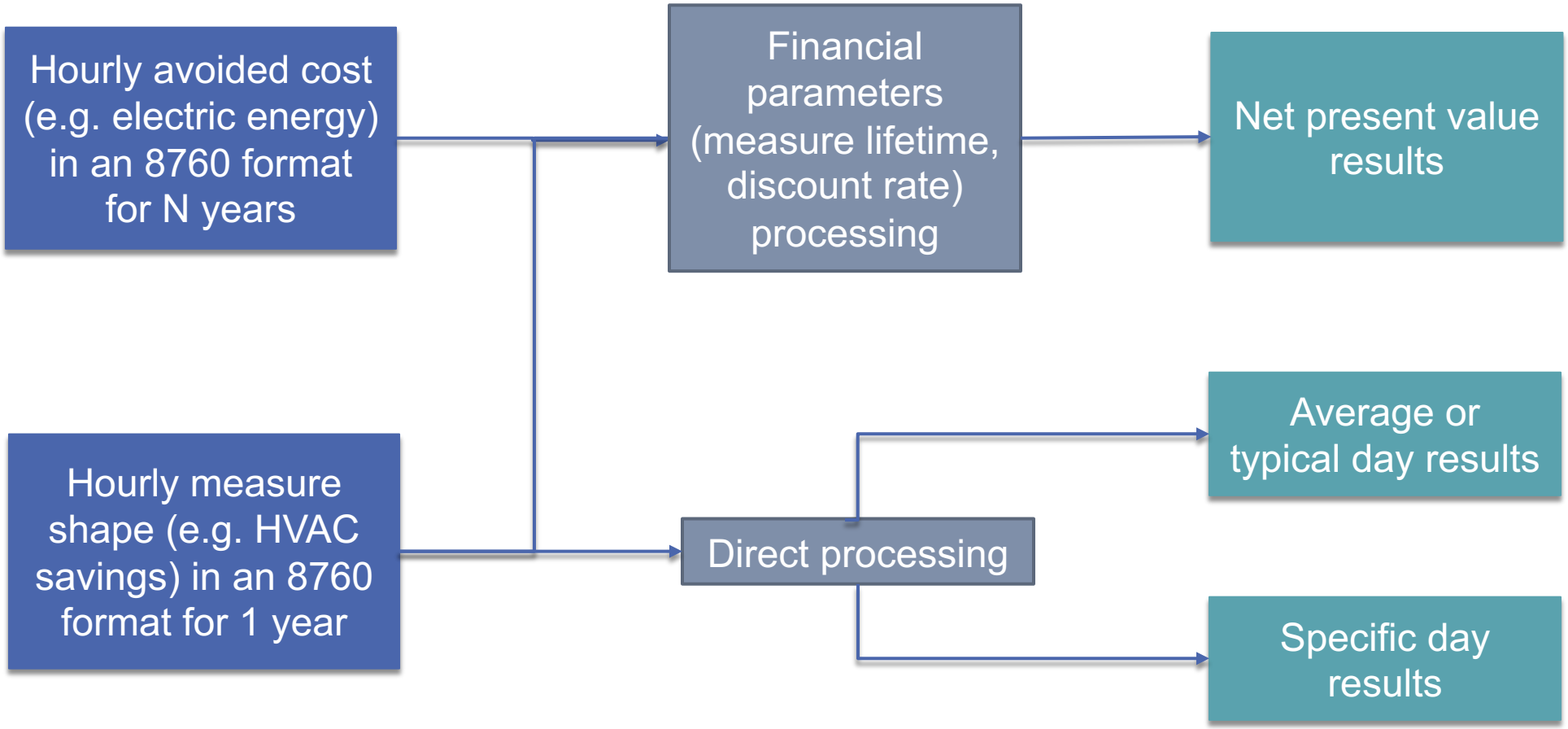
Time-Sensitive Value Calculator

Time-Sensitive Value Calculator

The Time-Sensitive Value Calculator (Calculator) — coupled with publicly available national data — allows users to **assess the hourly value of demand-side measures** throughout the United States using a consistent approach. The Calculator:

- Is a **publicly-available, free tool** that estimates the value of measures using hourly *electricity system* cost estimates.
- Uses **hourly profiles** of up to six measures and **monetizes their value** for five hourly value streams and one annual value stream, producing outputs in tabular and graphical formats.
- Is designed for **public utility commissions, state energy offices, utilities** and stakeholders to estimate the value of measures under future electricity system conditions.

Calculator data flow



- Monetize measure shapes by multiplying each hour's savings by the corresponding hour's cost from each value stream
- Costs can vary from one year to the next

Conceptual overview

Value Streams

- Avoided Electric Energy
- Deferred Electric Generation Capacity
- Deferred Electric Transmission Capacity
- Deferred Electric Distribution Capacity
- Avoided CO2 Emissions
- System Risk Mitigation (annual)

Measures

- Can be consumption, savings, generation
- Characterized by
  - Hourly shapes for 1 year – can come from ResStock and ComStock EULPs
  - Lifetimes

Calculator features

- The Calculator **monetizes one year of a measure shape** by multiplying each hour's demand by the corresponding hour's cost from each hourly value stream and then applying the annual factors.
- It does this for **each of the eight analysis years chosen by the user** and then **estimates the net present value (NPV)** of the total value of each measure over its lifetime.
- Users can **change generation mix over time** (inputs are avoided costs) to compare the value of measures in an evolving resource portfolios.
- Users can **also include or exclude avoided cost values** to compare the value of a measure with and without inputs (e.g., avoided cost of carbon).
- User guide has detailed instructions of **how to use the Calculator with inputs from ResStock and ComStock EULPs and Cambium**. This provides a default data set for the continental U.S.
- The Calculator can be used with **measures that generate electricity** (PV) and measures that **save electricity** (EE).

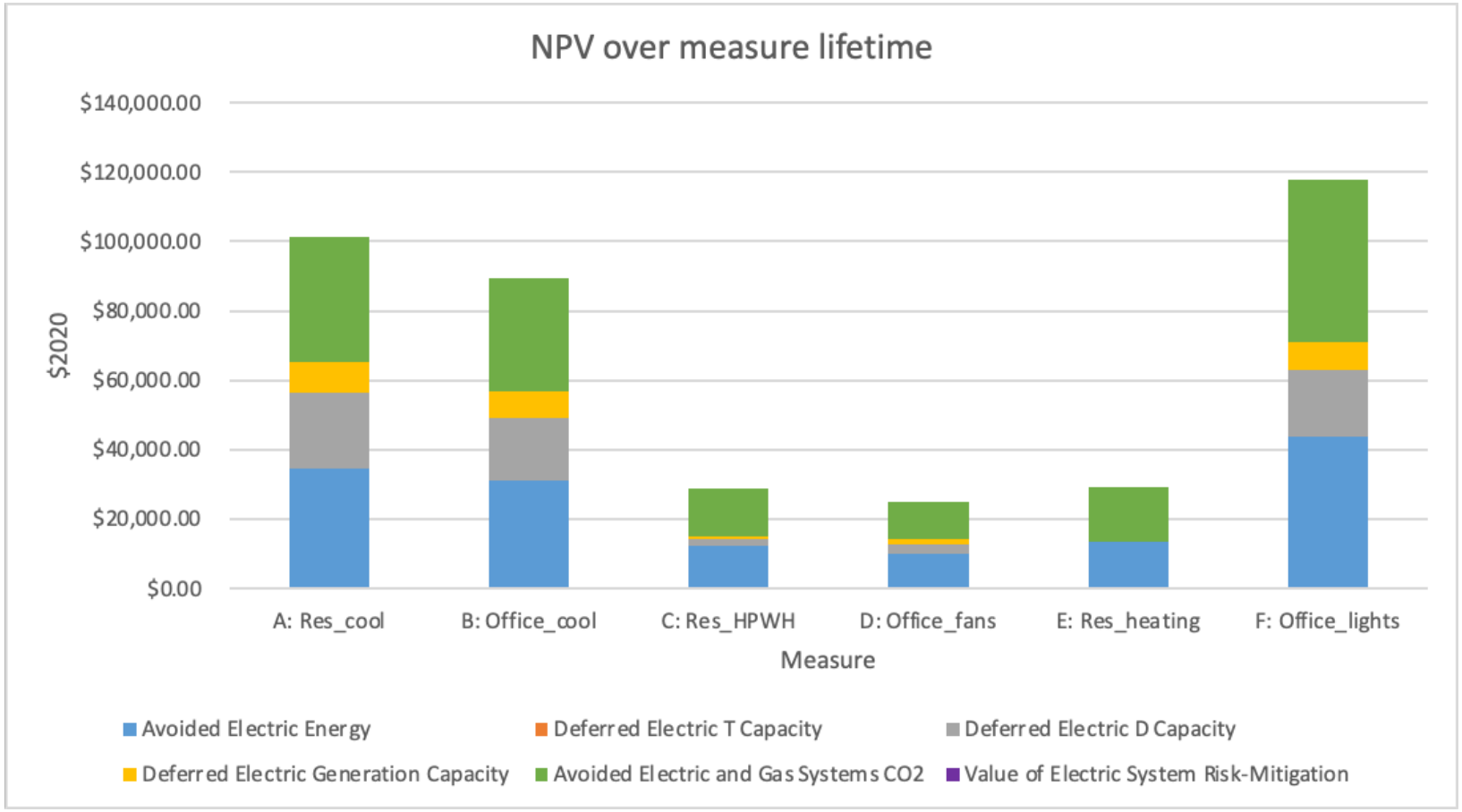
Types of analysis

		Calculator	
	Typical Analysis	Shape+	Shape Only
Timing of measure		✓	✓
Magnitude of measure	✓	✓	
Measure lifetime	(✓)	✓	

- The Calculator can create a variety of results. We focus on two of them here, and in the user guide.

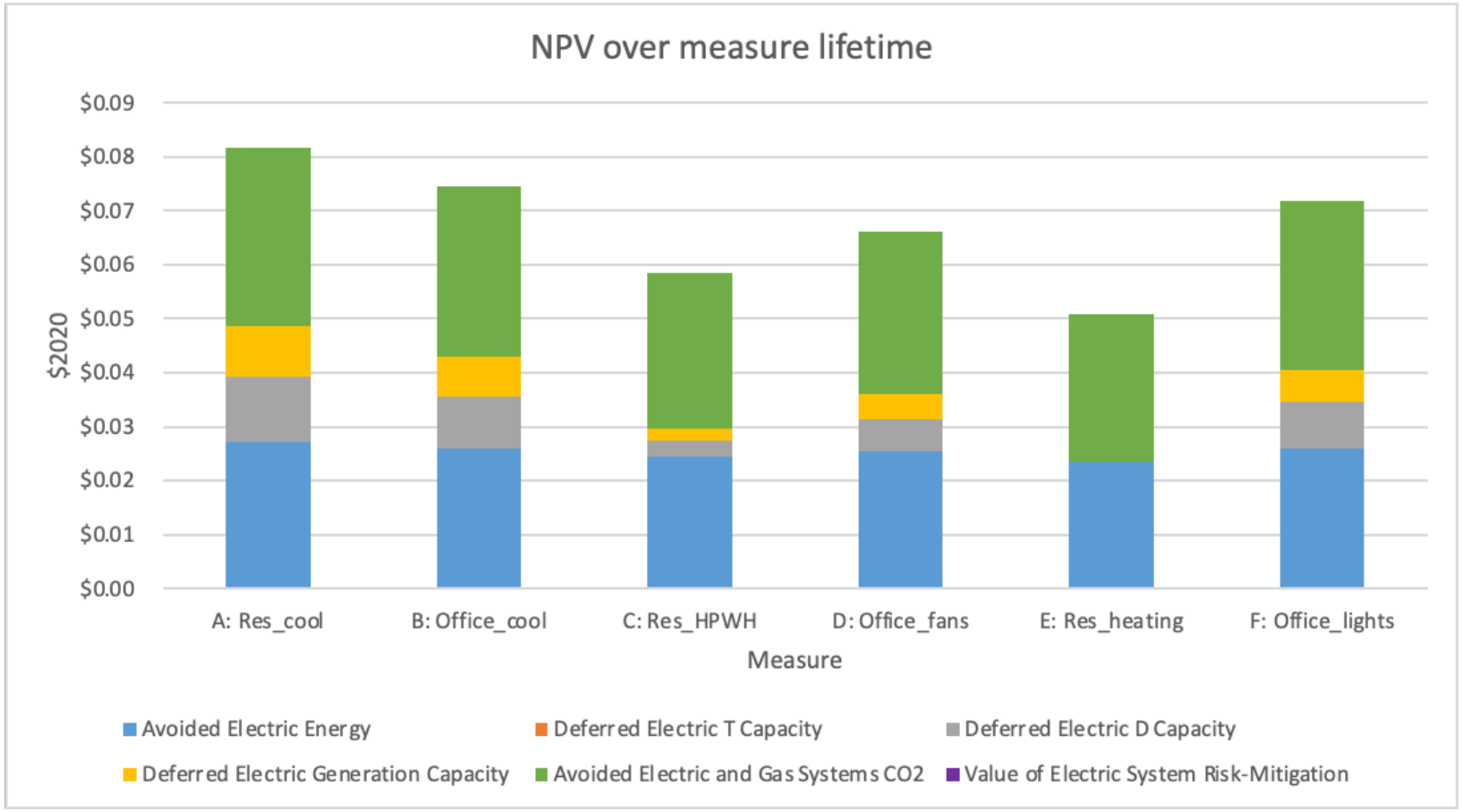
1. Comparison of the value of savings from different measure shapes and impact, taking into consideration the life of the measure – *Shape+*
2. Comparison of the value of savings from different measure shapes by isolating the timing of the measure impact – *Shape Only*

Example of Shape+ analysis



Measure	Savings (kWh/year)	Measure lifetime (years)
A: Residential cooling	100,000	17
B: Office cooling	100,000	15
C: Residential heat pump water heater	50,000	13
D: Office fans	50,000	9
E: Residential heating	50,000	17
F: Office lights	150,000	15

Example of Shape Only analysis



Measure	Savings (kWh/year)	Measure lifetime (years)
A: Residential cooling	1	1
B: Office cooling	1	1
C: Residential heat pump water heater	1	1
D: Office fans	1	1
E: Residential heating	1	1
F: Office lights	1	1

The Calculator is NOT:

- Building energy model
- Building level tool
- Building performance or project tracking database

- Optimization or dispatch model
- Cost-benefit analysis
- Simulation-based analysis

- Data dictionary
- Measure/end-use specific

Project workflow

Identify state need/interest in the Calculator

- Interviews with NYSERDA, Georgia PSC, Michigan PUC, Indiana PUC

Create technical advisory group to guide development of Calculator

- Public utility commission staff, utilities, and consultants (see Appendix)

Identify and test hourly data sources

- Cambium, ResStock and ComStock end use load profiles (EULP), regional sources for other inputs

Develop, test and refine Calculator with feedback from the technical advisory group

Develop user manual

Calculator Demo

Calculator demo – Introduction (1)

The Time Sensitive Value Calculator

Version: 1.7, January 2022

Authors: Natalie Mims Frick, Juan Pablo Carvallo, and Margaret Pigman

The Time Sensitive Value of Energy Efficiency Calculator (Calculator) is a publicly-available, free tool that estimates the value of up to six energy efficiency measures using hourly electricity system cost estimates for six value streams.

Input tabs

C1 - Param input	Model-wide parameter inputs (simulation years, discount rate, deflation rate, base dollar year); select measures and value streams for simulation; assign value to annual risk mitigation adder.
C2 - Cost data user	Hourly cost data in $/MWh for each value stream in all simulation years.
C3 - Shape data user	Hourly measure shapes (savings or consumption) for each measure.
C4 - Load data user	Hourly electricity system load at the busbar level for each simulation year.
C5 - Measure data	Measure names, descriptions, lifetimes, and annual energy savings or consumption.

Additional auxiliary file

File: Auxiliary workbook	Creating hourly costs from annual values and the system load shape. Creating hourly CO2 costs from a flat cost and hourly emissions. Normalizing hourly values to one. Converting 15 minute data to hourly.

Color coding

Tabs

orange	outputs - charts
blue	outputs - tables
red	inputs

Cells

blue	user inputs
white/gray	formulas; do not edit

Introduction tab orients the user

Results: Three tabs of visualizations

Results: Four tabs of tables

Intro | A1 Dashboard | A2 visuals 1 - meas svgs | A3 visuals 2 - shapes | B1 output-select day | B2 output-average day | B3 output-average day-month | B4 output-sun

Calculator demo – Introduction (2)

The Time Sensitive Value Calculator

Version: 1.7, January 2022

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Color coding

Tabs

orange	outputs - charts
blue	outputs - tables
red	inputs

Cells

blue	user inputs
white/gray	formulas; do not edit

Inputs: five tabs

B3 output-average day-month | B4 output-sum-hour | C1 param input | C2 cost data | C3 shape data | C4 load data | C5 measure data

Calculator demo – 8760 data

Cost for each value stream

		value_dollar_mwh							
hour_of_year	hour of day	2020	2022	2024	2026	2028	2030	2040	2050	month
1	1	15.67	2.35	1.85	2.11	2.69	2.18	2.25	2.23	1
2	2	15.47	2.27	1.75	2.02	2.59	2.08	2.05	2.04	1

- [x] Avoided Electric and Gas Systems CO2
- [x] Avoided Electric Energy
- [x] Deferred Electric D Capacity
- [x] Deferred Electric Generation Capacity
- [x] Deferred Electric T Capacity

Measure shape

measure	hour_of_day	hour_of_year	measure_shape_kW	select_shape_kW
A: Res_cool	1	1	0.082042908	0.082042908
A: Res_cool	2	2	0.019663361	0.019663361

Electricity system load

shap	hour_of_day	hour_of_year	20	20	20	20	20	20	20	20
Load	1	1	0.219363	0.220861	0.261755	0.228104	0.204097	0.17714	0.099035	0.055052
Load	2	2	0.221529	0.229037	0.26596	0.237574	0.215261	0.186234	0.074461	0.028138

Calculator demo – Auxiliary workbook

Assists users in converting data to the format the Calculator requires

Convert annual costs to hourly

Number of hours to distribute the annual costs across. 40 is typical.

40	top hours

load_shape

2020	2022	2024	2026	2028	2030	2040	2050
0.2193634	0.22086074	0.26175533	0.22810394	0.20409673	0.17714018	0.09903526	0.05505245
0.22152855	0.22903661	0.26595975	0.23757411	0.21526142	0.18623391	0.07446115	0.02813849

Annual avoided capacity cost ($/kW-yr) -->

37	37.7437	38.50234837	39.27624557	40.06569811	40.87101864	45.14703148	49.87040987
2020	2022	2024	2026	2028	2030	2040	2050
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

Convert emissions to dollars

Hourly carbon emissions (kg CO2/MWh)

2020	2022	2024	2026	2028	2030	2040	2050
390.50	121.10	35.80	79.30	53.70	32.00	30.50	51.00
346.70	103.20	47.30	30.30	37.40	30.20	68.40	30.10
353.10	383.80	60.60	362.00	826.30	29.90	77.60	762.50

Carbon cost ($/ton) -->

51	51	56	56	56	62	73	85
2020	2022	2024	2026	2028	2030	2040	2050
19.9155	6.1761	2.0048	4.4408	3.0072	1.984	2.2265	4.335
17.6817	5.2632	2.6488	1.6968	2.0944	1.8724	4.9932	2.5585
18.0081	19.5738	3.3936	20.272	46.2728	1.8538	5.6648	64.8125

Aggregate 15 min load shapes to hourly

month-day-hour	minute	15 min shape
010100	0	0
010100	15	0
010100	30	0

Shape+
original magnitude
the sum is the same as the sum of the input

month-day-hour	hourly	shifted hourly
010100	0	0
010101	0	0
010102	0	0

Shape+
specified magnitude
the sum of the output is set in the blue box

100,000 kWh/yr

hourly	shifted hourly
-	-
-	-
-	-

Shape Only
magnitude of one
the sum of the output is 1 kWh/yr

hourly	shifted hourly
0	0
0	0
0	0

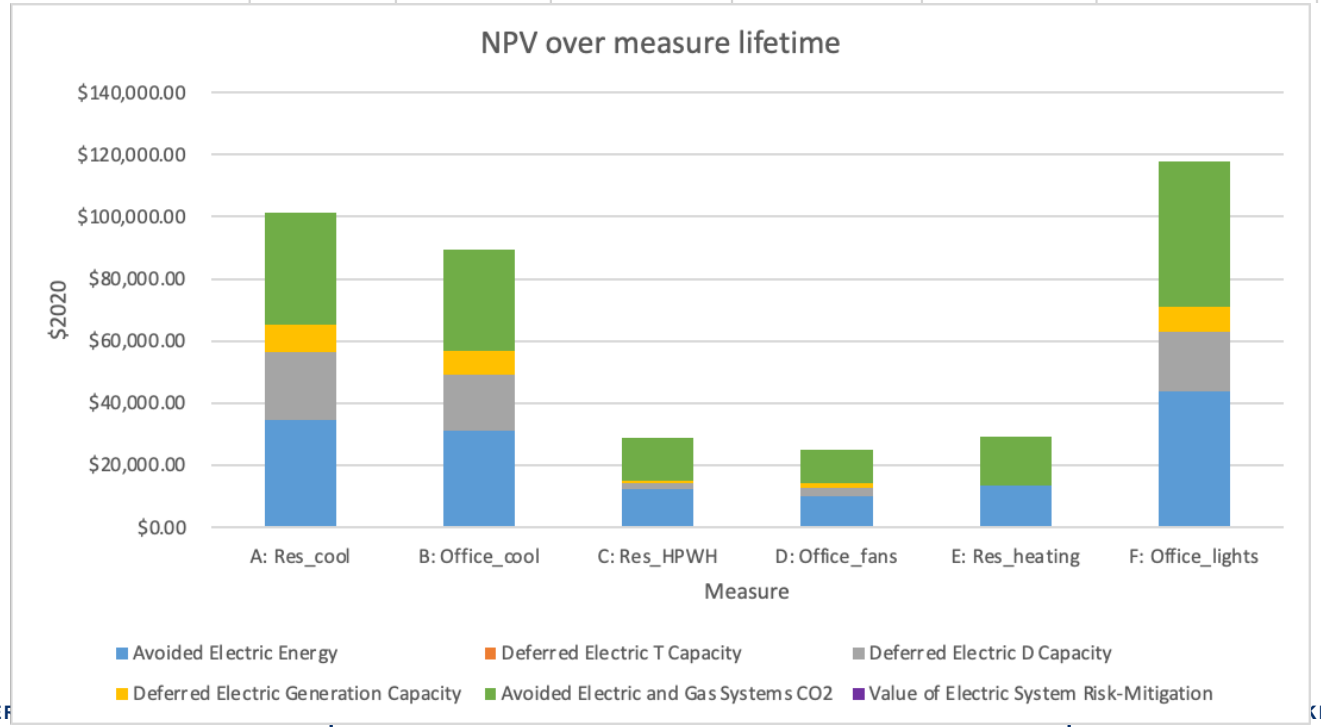
Calculator demo – Measures

Measure	Label	Description	Lifetime	Annual energy (kWh)	notes
Measure A	A: Res_cool	Residential cooling	17	100000	ResStock - TX 2018 AMY weather; TX TRM 9.0
Measure B	B: Office_cool	Medium and large office cooling	15	99994	ComStock - TX 2018 AMY weather; TX TRM 9.0
Measure C	C: Res_HPWH	Residential heat pump water heater	13	50010	ResStock - TX 2018 AMY weather; TX TRM 9.0
Measure D	D: Office_fans	Medium and large office fans	9	50001	ComStock - TX 2018 AMY weather; TX TRM 9.0
Measure E	E: Res_heating	Residential electric heating	17	50176	ResStock - TX 2018 AMY weather; TX TRM 9.0
Measure F	F: Office_lights	Medium and large office interior lighting	15	149583	ComStock - TX 2018 AMY weather; TX TRM 9.0

Calculator results – Net present value of a measure

Calculate Values

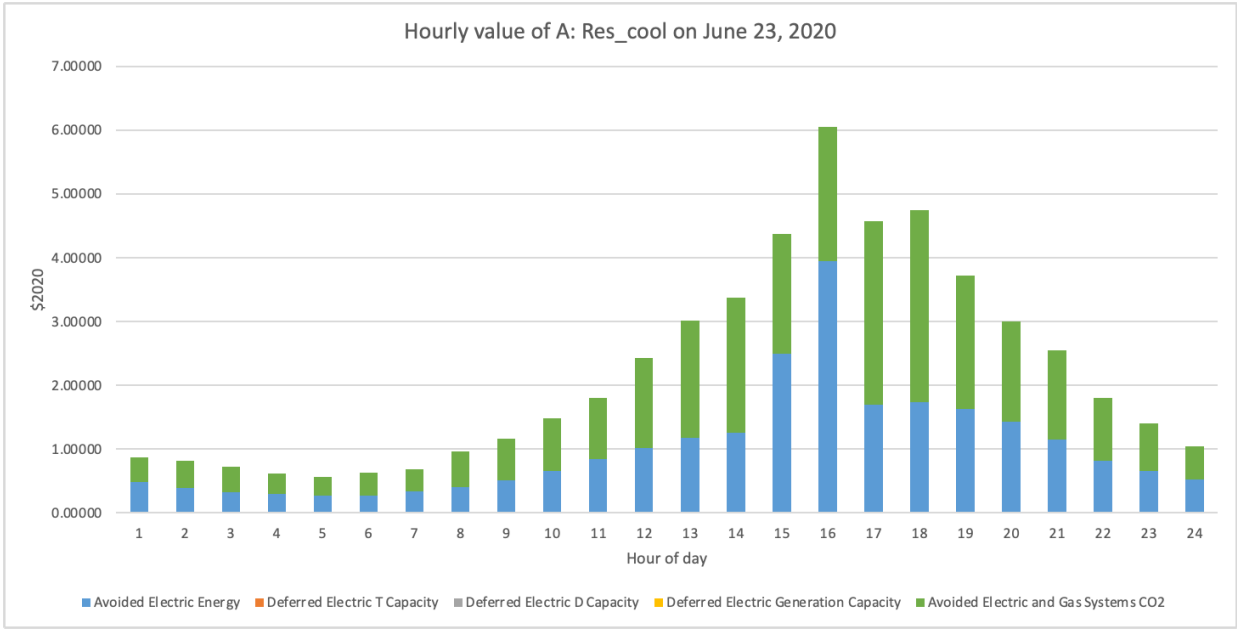
Net present value of savings							
		Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Value Stream		A: Res_cool	B: Office_cool	C: Res_HPWH	D: Office_fans	E: Res_heating	F: Office_lights
Avoided Electric Energy	Enabled	$34,593.49	$31,217.16	$12,302.68	$9,871.28	$13,650.57	$43,727.11
Deferred Electric T Capacity	Not Enabled	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Deferred Electric D Capacity	Enabled	$21,712.66	$18,032.83	$1,988.58	$2,843.23	$5.16	$19,401.28
Deferred Electric Generation Capacity	Enabled	$8,818.23	$7,549.26	$894.37	$1,531.81	$2.41	$7,740.05
Avoided Electric and Gas Systems CO2	Enabled	$36,033.16	$32,778.30	$13,641.62	$10,766.71	$15,520.55	$47,130.81
Value of Electric System Risk-Mitigation	Not Enabled	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Measure lifetime		17	15	13	9	17	15
Energy consumption or savings (kWh/yr)		100000	99994.44416	50009.63904	50001.16315	50176.11435	149583.2507



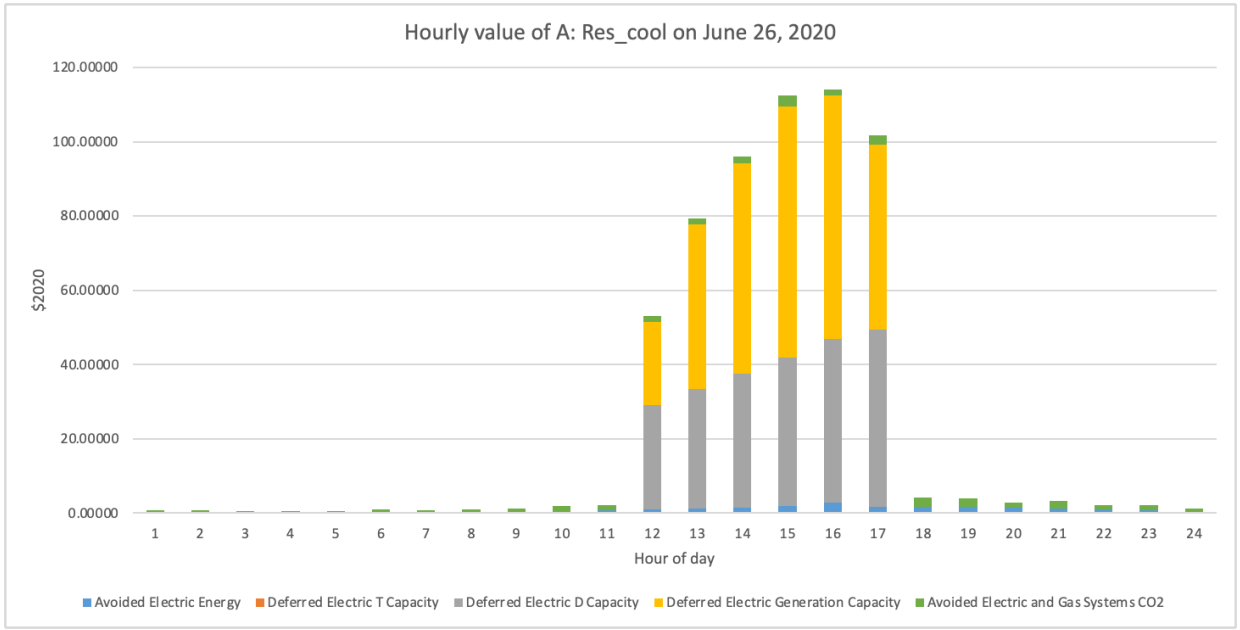
Calculator results – Savings for a specific date

Savings for a specific day/month/year	
	Start
Year	2020
Month	June
Day	23
Measure	A: Res_cool

Refresh this chart



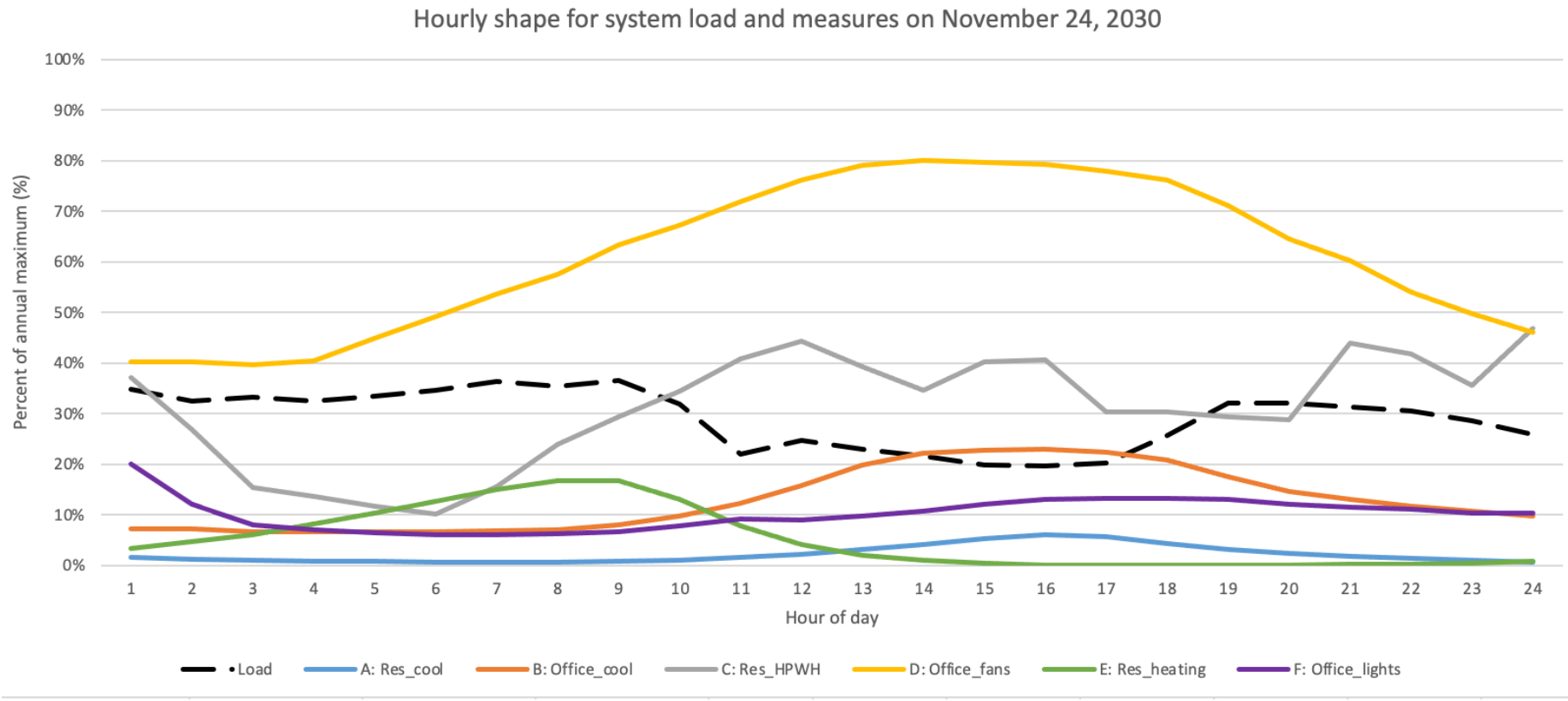
Results are also provided in a table format



Calculator results – Hourly system shape for a specific day

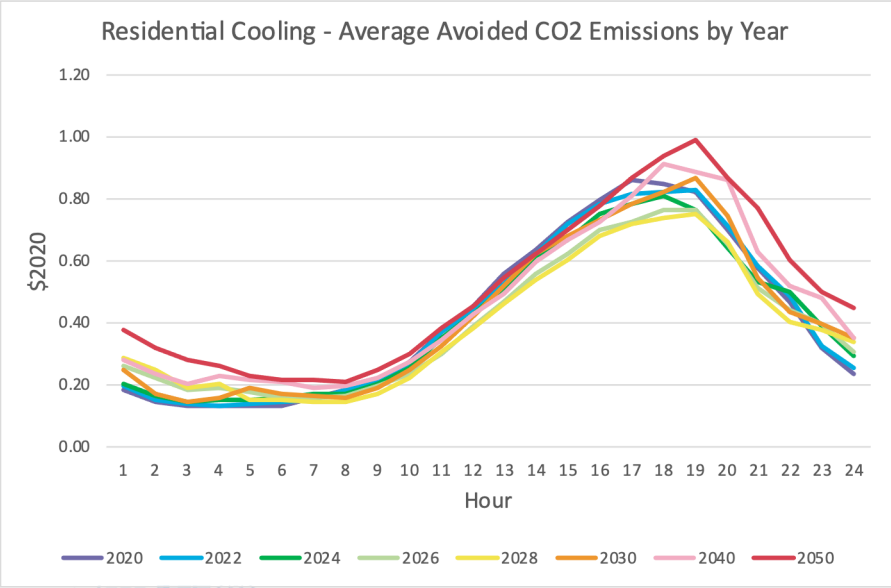
Shapes for a specific day/month/year		
	Start	End
Year	2030	
Month	November	
Day	24	

Refresh this chart



Calculator results – Average day

Average hourly value by measure and stream in $2020										
measure	stream	Hour	2020	2022	2024	2026	2028	2030	2040	2050
A: Res_cool	Avoided Electric Energy	1	0.15	0.16	0.16	0.18	0.19	0.14	0.14	0.22
A: Res_cool	Avoided Electric Energy	2	0.12	0.13	0.12	0.15	0.15	0.10	0.12	0.19
A: Res_cool	Avoided Electric Energy	3	0.11	0.11	0.11	0.12	0.12	0.09	0.11	0.17
A: Res_cool	Avoided Electric Energy	4	0.11	0.11	0.11	0.13	0.13	0.10	0.10	0.16
A: Res_cool	Avoided Electric Energy	5	0.11	0.11	0.11	0.13	0.13	0.12	0.11	0.14
A: Res_cool	Avoided Electric Energy	6	0.10	0.11	0.11	0.13	0.13	0.12	0.12	0.14
A: Res_cool	Avoided Electric Energy	7	0.11	0.11	0.12	0.13	0.14	0.14	0.15	0.14
A: Res_cool	Avoided Electric Energy	8	0.13	0.13	0.13	0.15	0.15	0.15	0.14	0.13
A: Res_cool	Avoided Electric Energy	9	0.16	0.16	0.16	0.18	0.18	0.18	0.14	0.14
A: Res_cool	Avoided Electric Energy	10	0.21	0.22	0.22	0.24	0.25	0.24	0.19	0.18
A: Res_cool	Avoided Electric Energy	11	0.27	0.29	0.29	0.34	0.35	0.32	0.25	0.23
A: Res_cool	Avoided Electric Energy	12	0.35	0.36	0.38	0.49	0.45	0.41	0.33	0.29
A: Res_cool	Avoided Electric Energy	13	0.42	0.43	0.46	0.80	0.52	0.50	0.40	0.34
A: Res_cool	Avoided Electric Energy	14	0.54	0.52	0.56	1.08	0.64	0.58	0.47	0.39
A: Res_cool	Avoided Electric Energy	15	0.65	0.67	0.67	1.19	0.70	0.66	0.52	0.44
	ded Electric Energy	16	0.65	0.67	0.66	1.12	0.75	0.72	0.57	0.49
	ded Electric Energy	17	0.64	0.67	0.69	0.97	0.79	0.75	0.60	0.54
	ded Electric Energy	18	0.66	0.70	0.72	0.92	0.83	0.81	0.71	0.60

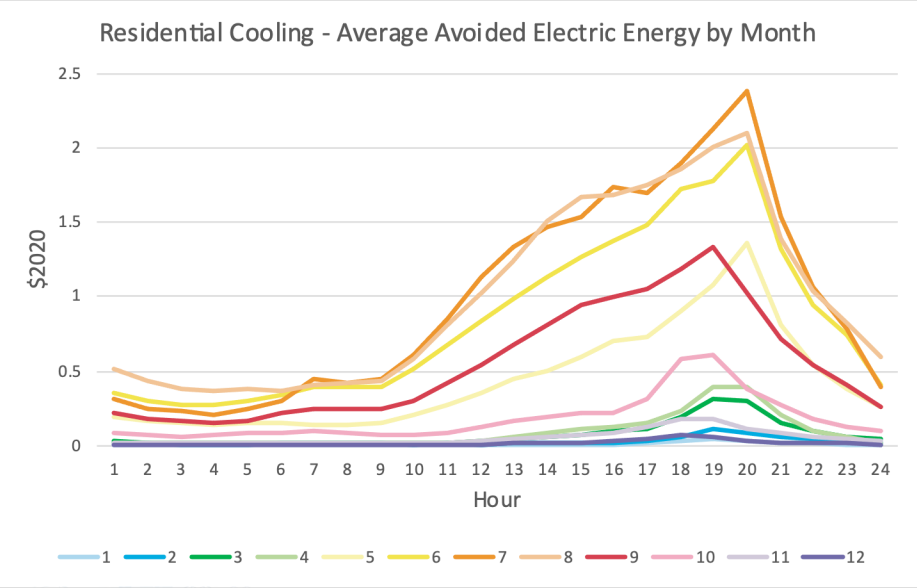


Average hourly value for all enabled measures and value streams by hour in each analysis year. (e.g., 1 am is the average of the hour ending 1 am for each year).

Calculator results – Average month

Average hourly value by measure and stream in $2020

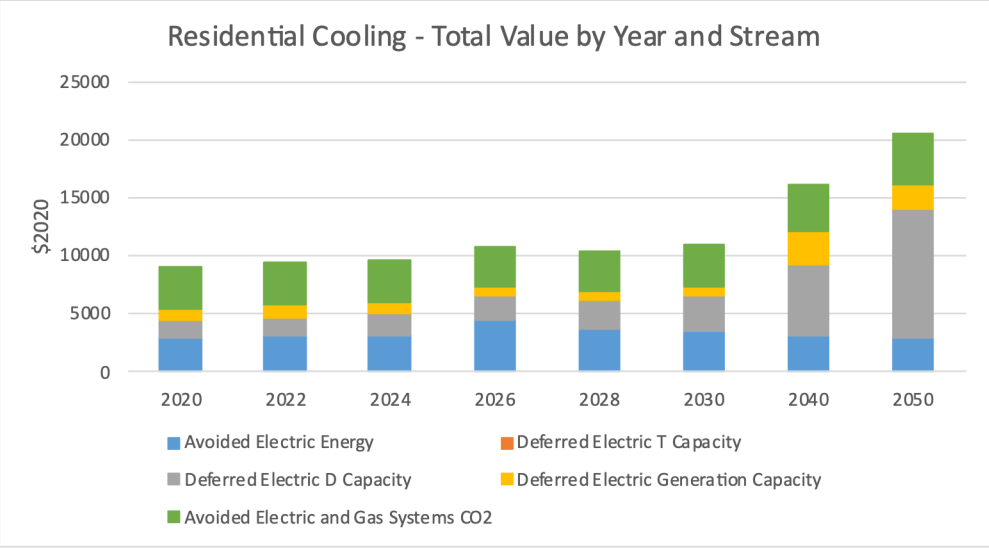
measure	stream	month	Hour	20	20	20	20	20	20	20	20
A: Res_cool	Avoided Electric Energy	1	1	0.00293	0.00309	0.00264	0.00331	0.00320	0.00298	0.00240	0.00251
A: Res_cool	Avoided Electric Energy	1	2	0.00192	0.00201	0.00194	0.00232	0.00243	0.00143	0.00135	0.00148
A: Res_cool	Avoided Electric Energy	1	3	0.00145	0.00154	0.00140	0.00174	0.00181	0.00129	0.00105	0.00107
A: Res_cool	Avoided Electric Energy	1	4	0.00128	0.00135	0.00125	0.00151	0.00159	0.00122	0.00089	0.00089
A: Res_cool	Avoided Electric Energy	1	5	0.00118	0.00122	0.00125	0.00140	0.00146	0.00117	0.00102	0.00080
A: Res_cool	Avoided Electric Energy	1	6	0.00105	0.00107	0.00107	0.00123	0.00127	0.00125	0.00088	0.00063
A: Res_cool	Avoided Electric Energy	1	7	0.00124	0.00136	0.00119	0.00139	0.00141	0.00141	0.00105	0.00084
A: Res_cool	Avoided Electric Energy	1	8	0.00150	0.00157	0.00154	0.00178	0.00190	0.00183	0.00146	0.00114
A: Res_cool	Avoided Electric Energy	1	9	0.00190	0.00198	0.00200	0.00217	0.00220	0.00211	0.00122	0.00084
A: Res_cool	Avoided Electric Energy	1	10	0.00265	0.00255	0.00226	0.00232	0.00236	0.00232	0.00115	0.00089
A: Res_cool	Avoided Electric Energy	1	11	0.00314	0.00321	0.00304	0.00306	0.00306	0.00310	0.00147	0.00122
A: Res_cool	Avoided Electric Energy	1	12	0.00431	0.00432	0.00420	0.00424	0.00427	0.00407	0.00223	0.00181
A: Res_cool	Avoided Electric Energy	1	13	0.00604	0.00613	0.00589	0.00603	0.00613	0.00543	0.00315	0.00257
A: Res_cool	Avoided Electric Energy	1	14	0.00882	0.00893	0.00832	0.00875	0.00886	0.00759	0.00463	0.00390
A: Res_cool	Avoided Electric Energy	1	15	0.01280	0.01295	0.01197	0.01273	0.01193	0.01029	0.00661	0.00552
A: Res_cool	Avoided Electric Energy	1	16	0.01940	0.01922	0.01806	0.01908	0.01757	0.01641	0.00944	0.00774
A: Res_cool	Avoided Electric Energy	1	17	0.02801	0.02780	0.02638	0.02814	0.02826	0.02763	0.01540	0.01409
	gy	1	18	0.03956	0.03956	0.03733	0.04258	0.03985	0.04023	0.02912	0.02517



Average hourly value for all enabled measures and value streams by hour in each month and analysis year. (e.g., 1 am is the average of the hour ending 1 am for each month).

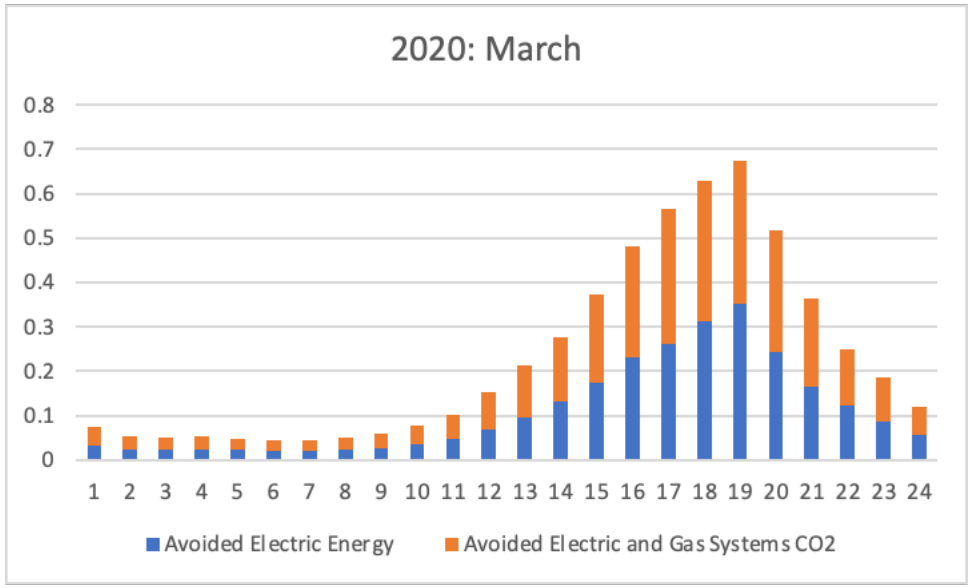
Calculator results – Sum of values

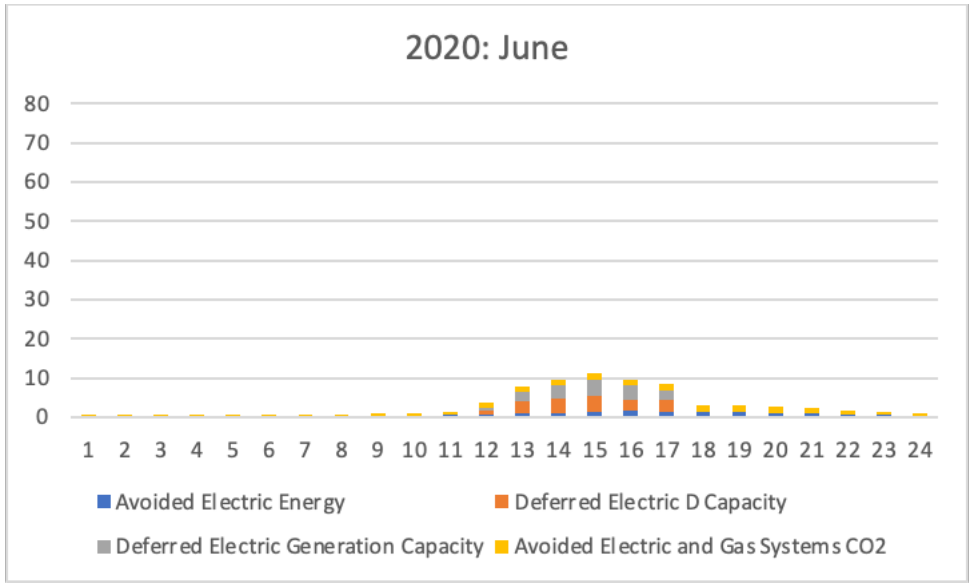
This tab provides the total value of the enabled measures and value streams for each hour of the day in all years in the analysis

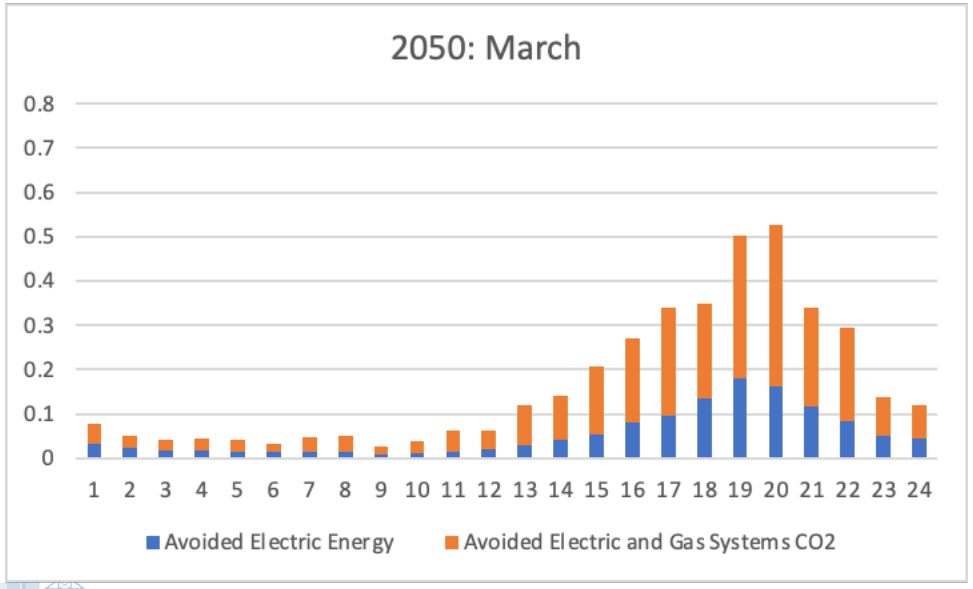


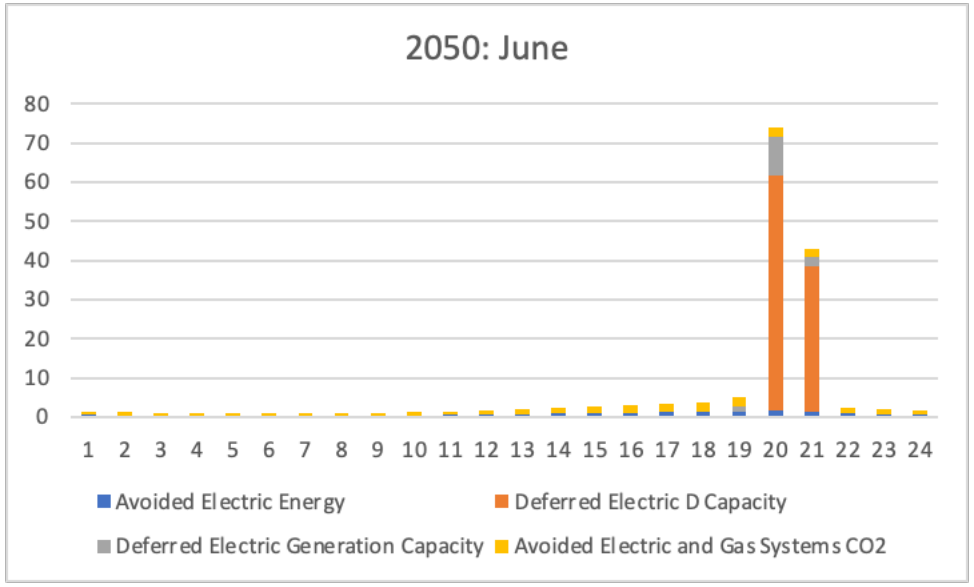
Total annual value by measure and stream in $2020									
measure	stream	2020	2022	2024	2026	2028	2030	2040	2050
A: Res_cool	Avoided Electric Energy	2878.35	2972.032	3034.344	4218.332	3596.994	3359.02	2968.225	2815.787
A: Res_cool	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
A: Res_cool	Deferred Electric D Capacity	1295.991	1505.148	1717.529	2022.298	2368.279	2902.768	5919.013	10537.66
A: Res_cool	Deferred Electric Generation Capacity	992.9561	1019.663	1018.006	782.2138	725.1646	644.9598	2591.083	2048.126
A: Res_cool	Avoided Electric and Gas Systems CO2	3496.501	3482.358	3411.229	3319.982	3260.55	3511.219	3820.447	4213.471
A: Res_cool	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0
B: Office_coo	Avoided Electric Energy	2859.591	2944.348	2978.335	4051.668	3470.642	3237.858	2699.551	2499.588
B: Office_coo	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
B: Office_coo	Deferred Electric D Capacity	1228.29	1426.742	1657.822	1924.483	2211.554	2556.824	3403.679	5888.29
B: Office_coo	Deferred Electric Generation Capacity	922.0766	945.1795	943.8068	715.7954	645.0914	543.6153	1631.719	1187.796
B: Office_coo	Avoided Electric and Gas Systems CO2	3459.186	3427.808	3348.944	3277.461	3193.126	3431.143	3587.861	3894.891
B: Office_coo	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0
C: Res_HPWH	Avoided Electric Energy	1302.244	1329.923	1310.76	1559.876	1510.916	1398.575	1079.712	966.5508
C: Res_HPWH	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
C: Res_HPWH	Deferred Electric D Capacity	151.9127	177.1487	208.5652	238.9038	278.6559	327.4952	845.9682	1970.042
C: Res_HPWH	Deferred Electric Generation Capacity	113.2817	116.1633	116.6367	90.89817	84.64491	75.64265	311.51	351.2992
C: Res_HPWH	Avoided Electric and Gas Systems CO2	1532.816	1530.707	1519.487	1553.736	1514.537	1592.356	1552.228	1645.246
C: Res_HPWH	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0
D: Office_fans	Avoided Electric Energy	1346.626	1379.618	1370.694	1720.77	1582.464	1471.079	1168.58	1059.951
D: Office_fans	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
D: Office_fans	Deferred Electric D Capacity	321.9624	375.0954	437.8867	509.2776	585.8494	673.0533	1075.962	2206.095
D: Office_fans	Deferred Electric Generation Capacity	238.7783	244.3784	244.053	186.6181	168.3866	143.1567	471.5784	430.3696
D: Office_fans	Avoided Electric and Gas Systems CO2	1600.887	1589.602	1569.009	1582.708	1543.729	1634.443	1637.684	1745.447
D: Office_fans	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0
E: Res_heatin	Avoided Electric Energy	1249.641	1264.614	1223.134	1390.325	1413.724	1314.202	1027.09	888.5893
E: Res_heatin	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
E: Res_heatin	Deferred Electric D Capacity	0.329819	0.375526	0.464276	0.523368	0.584197	0.614687	1381.886	3679.802
E: Res_heatin	Deferred Electric Generation Capacity	0.223629	0.226441	0.225462	0.168468	0.149396	0.293945	289.1644	677.4947
E: Res_heatin	Avoided Electric and Gas Systems CO2	1445.086	1416.1	1461.589	1506.714	1479.36	1536.279	1547.76	1577.44
E: Res_heatin	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0
F: Office_light	Avoided Electric Energy	4138.955	4240.285	4233.53	5408.49	4810.854	4484.231	3431.919	3037.463
F: Office_light	Deferred Electric T Capacity	0	0	0	0	0	0	0	0
F: Office_light	Deferred Electric D Capacity	1337.763	1555.109	1857.358	2114.415	2388.98	2649.905	2482.621	4952.02
F: Office_light	Deferred Electric Generation Capacity	969.7412	990.7154	985.9658	733.9122	640.5699	522.2146	1183.728	985.0922
F: Office_light	Avoided Electric and Gas Systems CO2	4965.642	4883.687	4791.312	4773.64	4588.655	4953.719	4858.755	5146.985
F: Office_light	Value of Electric System Risk-Mitigation	0	0	0	0	0	0	0	0

Residential cooling value over time









ELECTRICITY MARKETS & POLICY

Questions?

ELECTRICITY MARKETS & POLICY

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Appendix

Technical Advisory Group

- Hawaii Public Utility Commission
- Georgia Public Utility Commission
- Michigan Public Service Commission
- Xcel Energy
- Synapse Energy Economics
- Energy and Environmental Economics
- Department of Energy
- Tom Eckman Consulting

Calculator formulas (1)

For the five hourly value streams, the annual value of the stream for a measure in year *y* is

$$V_y = \sum_{h=1}^{8760} \frac{M_h * V_h}{(1+i)^{(y-y_0)}} * (1+ll)$$

Where:

V_y is the value of the value stream in year *y*

M_h is the measure savings or consumption in hour *h*

V_h is the value of the value stream in hour *h*

i is the inflator/deflator for converting to dollars of the base year

y_0 is the base dollar year

ll are the line losses

Calculator formulas (2)

For the electric system risk mitigation, the annual value for a measure in year *y* is

$$R_y = \sum_{j=1}^{5} V_{jy} * (1 + r)$$

Where:

R_y is the value of electric system risk mitigation in year *y*

V_{jy} is the annual value of value stream *j* in year *y*

r is the risk system mitigation multiplier

Finally, the net present value of the measure over its lifetime is

$$NPV = \sum_{y=1}^{eul} \frac{T_y}{(1 + d)^{(y-1)}}$$

Where:

NPV is the net present value of a measure over its lifetime

eul is the measure's lifetime

T_y is the total annual value from all value streams in year *y* of the analysis

d is the discount rate